MAUSAM, **74**, 2 (April, 2023), 397-410

MAUSAM

DOI : https://doi.org/10.54302/mausam.v74i2.6010
Homepage: https://mausamjournal.imd.gov.in/index.php/MAUSAM

UDC No. 551.553.21 : 551.515.9

Impact outlook of Asian monsoon for disaster resilience

SANJAY SRIVASTAVA and SAPNA DUBEY

United Nations Economic and Social Commission for Asia and the Pacific, Bangkok 10200, Thailand

e mails : srivastavas@un.org; sapnadubey14@gmail.com

सार — एशियाई ग्रीष्मकालीन मॉनसून पूरे एशिया में मानव जीवन और कृषि अर्थव्यवस्थाओं को प्रभावित करता है। ये प्रभाव मॉनसून की विसंगतियों से संचालित होते हैं जो ऋतुनिष्ठ वर्षा, सतह के तापमान और बाढ़, सूखा और उष्णकटिबंधीय चक्रवातों की घटनाओं के रूप में प्रकट होते हैं। एक प्रबलमॉनसून के परिणामस्वरूप कृषि उत्पादन में वृद्धि, आर्थिक विकास, वस्तुओं की कीमतों में कमी और राष्ट्रीय मुद्रास्फीति के स्तर के साथ-साथ भूजल में वृद्धि और जलाशयों में जल भंडारण करने जैसे कई सकारात्मक परिणाम सामने आते हैं। एशियाई ग्रीष्मकालीन मॉनसूनका पूर्वानुमान करते समय एशिया में सभी क्षेत्रों के निर्णय निर्माताओं द्वारा प्राथमिकता दी गई है जिससे कि प्रभाव पूर्वानुमान को अधिक महत्व मिले क्योंकि यह आपदा जोखिमों से निपटने के लिए विशेष रूप से महत्वपूर्ण है। 'मॉनसूनकैसा रहेगा' से 'मॉनसून क्या करेगा' से प्रतिमान बदलता है, आसन्न चरम घटनाओं के प्रबंधन के लिए एशियाई देशों को बेहतर ढंग से तैयार करने के लिए मूल्यवान अंतर्दृष्टि प्रदान करता है।

इस शोध पत्र में बताया गया है कि एशियाई मॉनसून के लिए प्रभाव के दृष्टिकोण का प्रभावी ढंग से उपयोग कैसे किया जा सकता है। इससे पता चलता है कि कैसे जोखिम और खतरों के मानचित्रों के साथ ऋतुनिष्ठ पूर्वानुमान और जोखिम और भेद्यतासंकेतक कृषि, ऊर्जा, स्वास्थ्य, जल और आपदा प्रबंधन सहित विभिन्न क्षेत्रों के लिए संभावित जोखिम परिदृश्यों की समझ को बढ़ा सकते हैं। ऋतुनिष्ठ पूर्वानुमानों की उपलब्ध सटीकता और सूचना की सीमाओं को ध्यान में रखते हुए, प्रभाव दृष्टिकोण से प्रदान की गई जानकारी को प्रारंभिक आकलन के रूप में समझा जाना चाहिए। यह शोध पत्र संभावित प्रभाव के डेटा के साथ ऋतुनिष्ठ, उप-ऋतुनिष्ठ, मध्यम और लघु अवधि के पूर्वानुमानों के निर्बाध एकीकरण के लिए मामला बनाता है। इसका उद्देश्य करीबी निगरानी और लक्षित नीतिगत कार्रवाईयों को सक्षम करना है।

ABSTRACT. The Asian summer monsoon impacts the human lives and agrarian economies throughout Asia. These impacts are driven by monsoon anomalies which are manifested in terms of the seasonal precipitation, surface temperatures and the occurrences of floods, droughts and tropical cyclones. A strong monsoon results in various positive outcomes like increased agricultural produce, economic growth, reduced commodity prices and national inflationary levels as well as increased ground water and restored reservoirs. While predicting the Asian summer monsoon has been prioritized by decision-makers across sectors in Asia, impact forecasting must gain greater significance as it is particularly important to tackle disaster risks. The paradigm shifts from ‘what monsoon will be to what monsoon will do provides valuable insights to better prepare Asian countries for managing impending extreme events.

The paper brings out how impact outlook for Asian monsoon can be effectively utilized. It shows how seasonal forecasts overlaid with risk and hazards maps and indicators on exposure and vulnerability can enhance understanding of potential risk scenarios for various sectors, including agriculture, energy, health, water, and disaster management. Noting the limitations of accuracy and information available from seasonal forecasts, the information provided from impact outlook should be understood as preliminary assessments. The paper makes a case for seamless integration of seasonal, sub-seasonal, medium, and short terms forecasts with the data on potential impact. This is aimed at enabling close monitoring and targeted policy actions.

Key words – Impact forecasting, Disaster risk, Hazard maps, Seasonal outlook, Preparedness.

1. Introduction

ESCAP’s flagship publication, Asia-Pacific Disaster Report 2019 captures a comprehensive picture of both slow-onset and extreme event disaster risk in the Asia-Pacific region for the first time. Annualized economic losses more than quadruple to **USD$675 billion** when slow onset disasters are added to the region’s riskscape (Fig. 1). As climate change interacts with environmental degradation, slow onset disaster such as agricultural

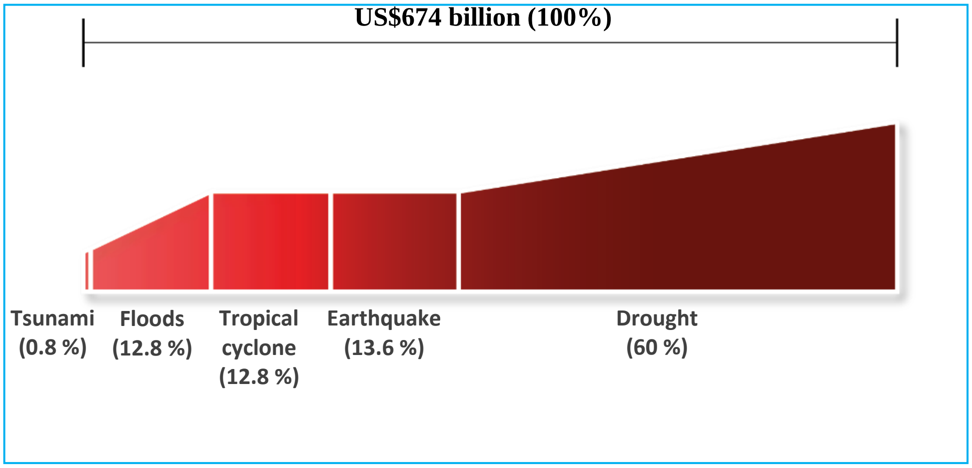


Fig. 1. Asia-Pacific regional riskscape (average annual losses) - volumetric analysis
Source : United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), based on probabilistic risk assessment.
Note : Volumetric analysis is a measurement by volume (impacted population, geographical area and economic losses)

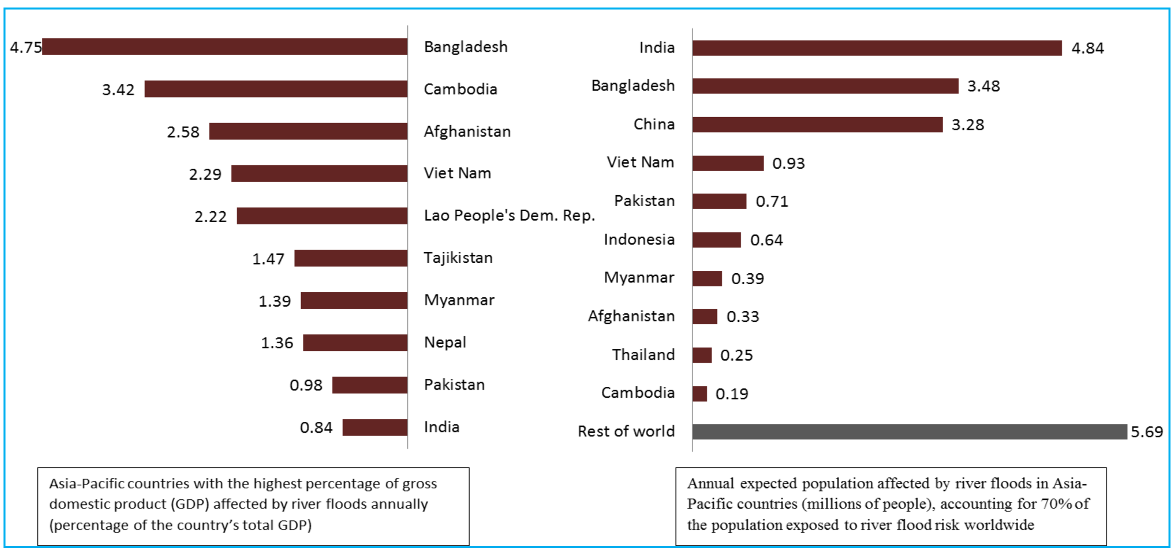


Fig. 2. Percent of GDP (left), expected number of people (millions, right) affected by floods annually
Source : UNESCAP based on World Resource Institute Flood database

droughts intensify and expands in terms its impacts to larger population, geographical areas and economic/social implications.

Floods in the Asia-Pacific region have been most frequent and devastating both in terms of fatalities and economic losses. Globally, 10 out of the top 15 countries with the most people and economies exposed to annual river floods are in the Asia-Pacific region. Countries facing the highest flood risks in the region are India, Bangladesh, China, Viet Nam, Pakistan, Indonesia, Myanmar, Afghanistan, Thailand and Cambodia (UNESCAP, 2019). The Asia-Pacific Disaster

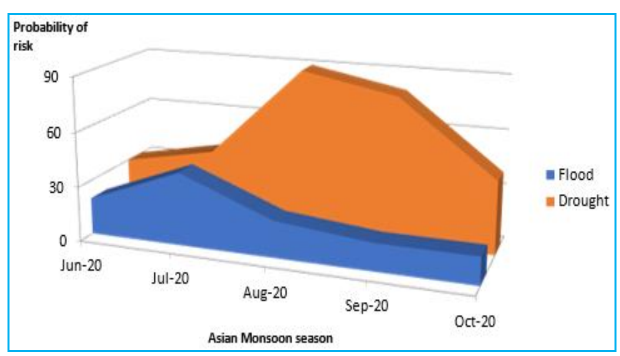


Fig. 3. Risk probability of floods and drought during the Asian monsoon (June-October, 2020)

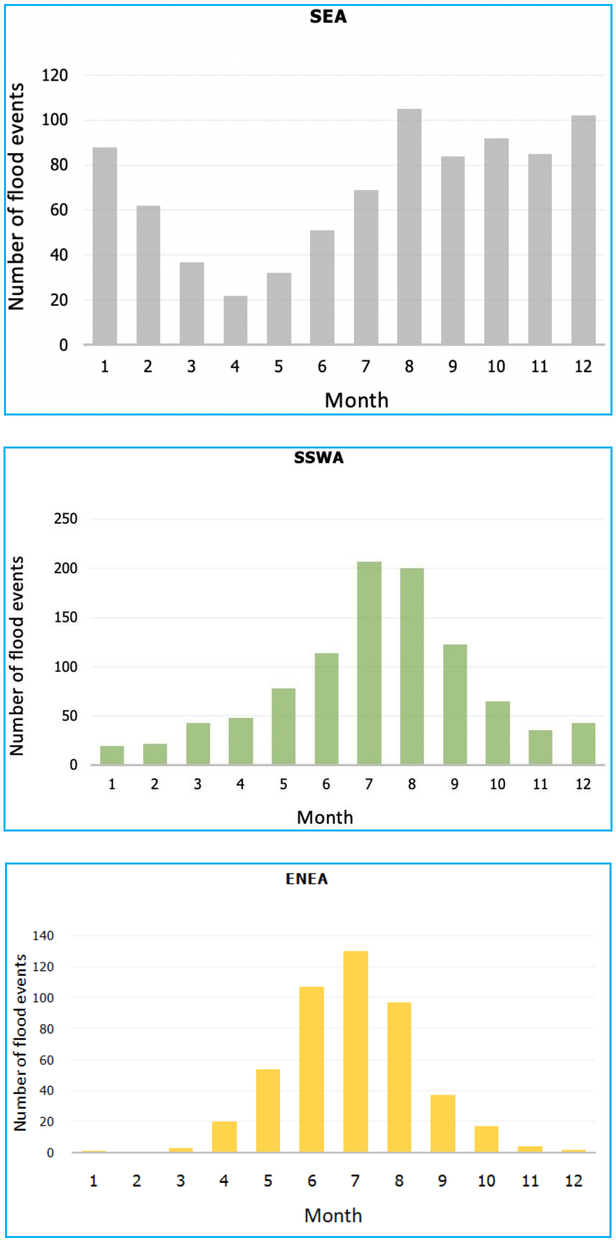


Fig. 4. Number of Flood Events in South-East Asia (SEA), South and South-West Asia (SSWA) and East and North-East Asia (ENEA), 1970-2021.
Source : EM-DAT (Accessed on 6th December, 2021)

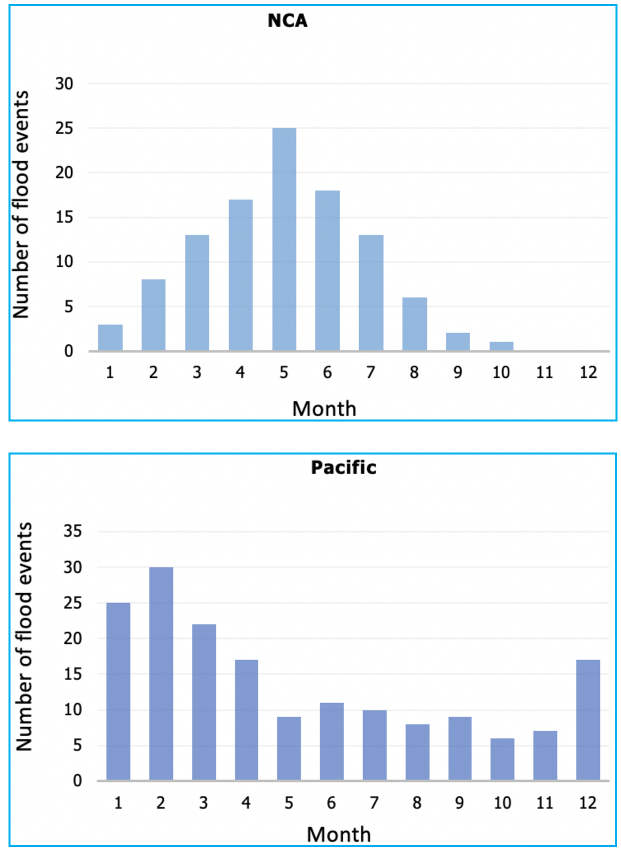


Fig. 5. Number of Flood Events in NCA and in the Pacific, 1970-2021.
Source : EM-DAT (Accessed on 6th June, 2020)

Report 2019 forecasts a substantial increase in flood-related losses, with the problems expected to become worse by 2030 (Fig. 2). China, India, Bangladesh and Pakistan will experience losses two to three times greater than in the reference year of 2010. Under the severe climate change scenario, India will be the worst affected, with annual losses of nearly US$50 billion, followed by China, Bangladesh and Pakistan. The floods can be analyzed by country, as excess water spreads across the region's major river basins and crosses national frontiers. Under the moderate and severe climate change scenarios, the transboundary flood losses will be 2 to 6 times greater in the Ganga-Brahmaputra and Meghna basin; 1.5 to 5 times in the Indus basin: 1.2 to 2 times in the Mekong basin; and 1.1 to 1.5 times in the Amur basin (UNESCAP, 2017).

Monsoon anomalies are key drivers of climate risk in Asia. The occurrences of floods and droughts, from May to October here, coincide with the Indian sub-continent and East Asian monsoon. In order to obtain useful information on flood and drought risks from seasonal forecast for precipitation, **it is essential to understand temporal risk profiles in different parts of the Asia-Pacific region**. This seasonal forecast captures the critical time domains. However, the risk of floods and droughts varies from year to year and more importantly place to place (Fig. 3). Therefore, the main objective of the impact forecasting is to capture these elements of the risks with its spatial and temporal attributes.

Analysis of historical flood and drought events between 1970 and 2021 show that in South-East

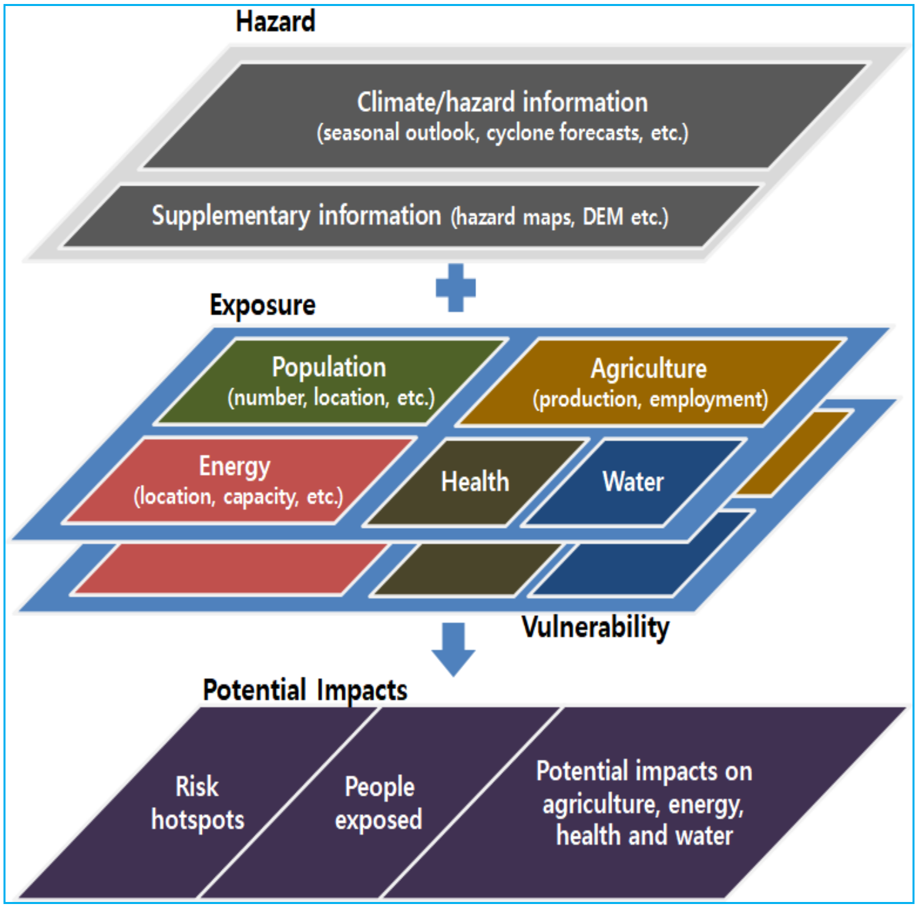


Fig. 6. Visualization of the concept of impact-based forecasting

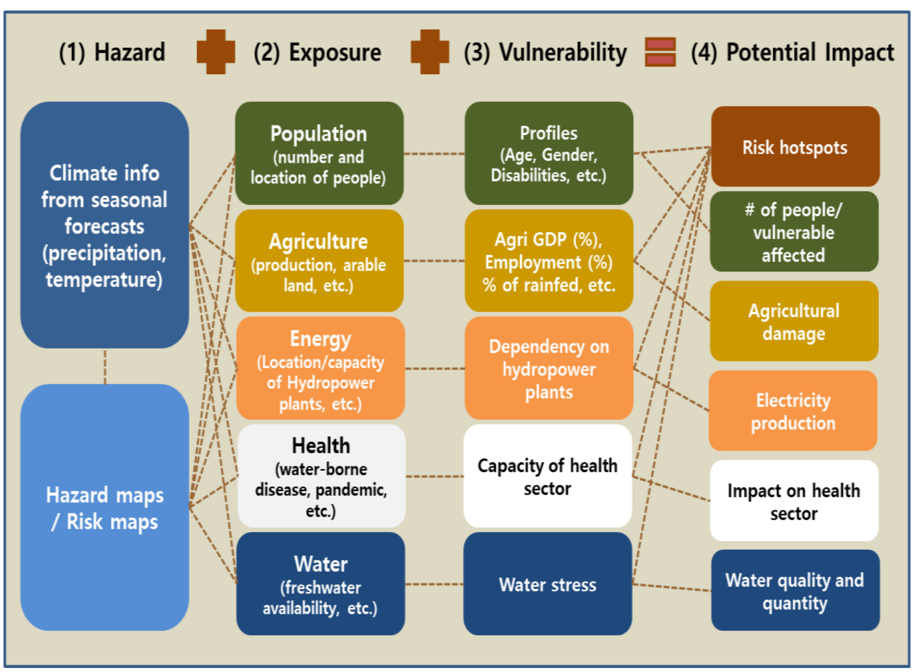


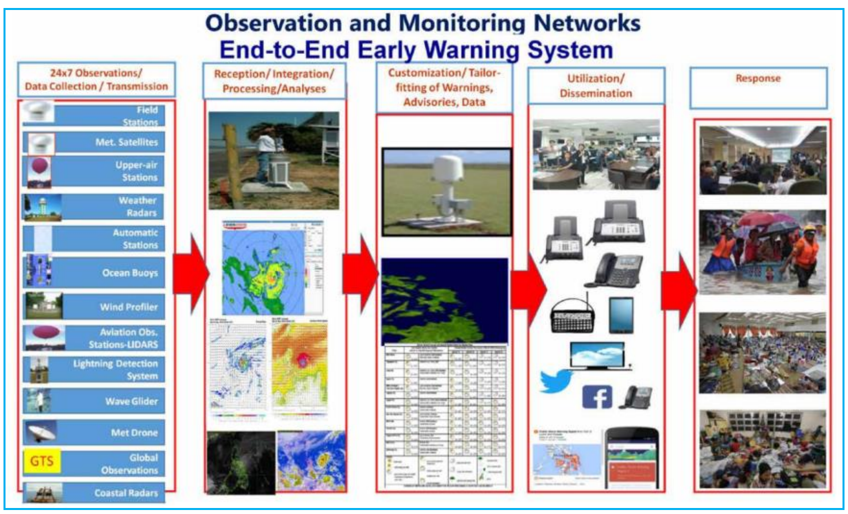
Fig. 7. Conceptual framework of impact outlook

Box 1 : PAGASA in the Philippines : A comprehensive data management system

As part of the endeavor of the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) to advance impact-based forecasting and early warning services, the agency has developed **an integrated system called GeoRiskPH**, which combines database management with analytics for impact-based forecasting. Data is collected from PAGASA assets, such as field stations and weather radars that generate weather or hazard forecasts and channeled into the GeoRiskPH database.

Beyond data collection, **PAGASA also works on developing hazard maps for floods, typhoons and storm surges**. Such hazard data can be analyzed within the integrated system alongside data on exposure and vulnerabilities to estimate risks. The various data layers are processed into warnings that are tailored towards the needs of specific agencies. The insights gathered are then disseminated to the public to stimulate early action.

Furthermore, the Philippines has enacted a Disaster Reduction and Management Act which mandates the formation of a multi-sectoral National Disaster Risk Reduction and Management Council (NDRRMC), in coordination with subnational-level committees. NDRRMC includes representatives from relevant agencies responsible for coordinating early action within their respective sectors. PAGASA works with the NDRRMC and subnational committees to increase disaster preparedness among local communities and sectoral stakeholders.



Box Figure : PAGASA's end-to-end approach to impact-based forecasting
Source : UNESCAP, WMO, Manual for Operationalizing Impact-based Forecasting and Warning Services

Asia (SEA), floods were frequent from August to January, with drought events largely reported in the first quarter (Fig. 4). In South and South-West Asia (SSWA) and East and North-East Asia (ENEA), flood events were concentrated during the summer monsoon season and peaked in July; and droughts were most frequent from early spring to the summer monsoon season. In North and Central Asia (NCA), about one fourth of flood events were recorded in May and in the Pacific, floods were most frequent during the winter from January to March (Fig. 4).

2. Data and methodology

The WMO Guideline on Multi-hazard Impact-based Forecast and Warning Services introduces the key concept of **impact-based forecasts** (World Meteorological Organization, 2015). It suggests including temporal and spatial exposure and their vulnerability to hazard information for understanding risk of impact. It summarized the key focus of impact-based forecast and warning services as **what the weather will do, in comparison to the focus of historical weather services on what weather will be**. Examples of operationalizing impact-based forecasting in Asia Pacific include countries like the Philippines and Indonesia. Box 1 presents the **Philippines case study** wherein data management system is put in place to advance impact-based forecasting.

For impact outlook of the Asian monsoon, the regional or sub-regional level seasonal precipitation and temperature forecast form the base hazard layer. In this regard, the seasonal forecasts from WMO's Regional

TABLE 1

Impact outlook and dataset used

Sectors	Potential Impact	Datasets
Population (DRR)	Population exposed to above-normal precipitation	SASCOF Seasonal Outlook 2020; WorldPop population data
	Vulnerable population exposed to drought	SASCOF Seasonal Outlook 2020; WorldPop population data; Subnational HDI
	Vulnerable people with poverty and malnutrition exposed to drought in Cambodia	WMO Asia-Pacific Seasonal Outlook 2020; Demographic and Health Surveys (DHS) Programme for Cambodia 2014
Agriculture	Major agricultural system exposed to high probability of flood events	SASCOF Seasonal Outlook 2020; AQUAMAPS Major agricultural system 2010
	Area actually irrigated exposed to high precipitation	SASCOF Seasonal Outlook 2019 and 2020; AQUAMAPS Global maps of irrigation area 2013
	Desert locusts as threat to agriculture areas and desert locusts developed during high rainfall	SASCOF Seasonal Outlook 2020; Desert locusts map 4th June, 2020
Energy	Solar and wind power plants exposed to drought	SASCOF Seasonal Outlook 2019 and 2020; ESCAP Energy Portal on hydro power plants data 2018
Health	Malaria incidence rates and high rainfall	SASCOF Seasonal Outlook 2020; WHO Changes in malaria incidence rates 2016
	Cascading impacts of climate hazards and COVID	SASCOF Seasonal Outlook 2020; John Hopkins University and ESRI COVID-19 data
Water	Major rivers areas exposed to drought	SASCOF Seasonal Outlook 2020; AQUAMAPS Major rivers of the world
	Water stress and seasonal forecast	SASCOF Seasonal Outlook 2020; WRI Aqueduct water stress projections data for 2020

Climate Outlook Forums (RCOFs) in Asia have been used for regional and subregional impact outlook of climate-related hazards. The concept, methodology and cases were presented during the 16th session of the South Asian Climate Outlook Forum (SASCOF) in April 2020 and the 16th session of the Forum on Regional Climate Monitoring, Assessment and Prediction for Asia (FOCRA-II) in May 2020.

The impact outlook aims to assess and understand the potential impacts of climate hazards on population, agriculture, energy, health and water sectors. Fig. 6 depicts the concept for this assessment. Based on hazard information acquired from seasonal forecasts and hazard/disaster risk maps, exposure and vulnerability indicators are overlaid to assess potential impacts of climate hazards on the sectors. In the exposure analysis, the methodology decodes the probabilistic expression and interprets the probabilistic forecasts. This is done by taking into account the tercile categories and their chances of occurrence (UNESCAP, 2021).

The Global Framework for Climate Services of WMO identify (1) agriculture and food security, (2) disaster risk reduction, (3) energy, (4) health and (5) water as five priority areas of climate services which provide climate information to help make climate smart decisions. In line with the framework, a conceptual framework for impact outlook based on seasonal forecasts is presented below (Fig. 7).

As explained in Figs. 6 and 7, it is proposed to use (1) seasonal forecast products together with hazard/disaster risk maps as hazard layer; and (2~3) demographic profile and various indicators on agriculture, energy, health and water sectors as exposure and vulnerability layers to get (4) potential impacts of climate hazards. Some examples of impact outlook based on seasonal forecast products are summarized below with the related datasets (Table 1).

Seasonal forecasts also have limitations in terms of their predictability. For example, they express probabilities of above or below normal precipitation in certain locations. Also, decision-making at the national and local levels will require fine-grained high-resolution spatial information, not only for hazards but also for exposure and vulnerability characteristics. Nevertheless, when seasonal forecasts on climate conditions are combined with the location’s hazard/risk, exposure and vulnerability information, it can help identify risk hotspots for climate-related hazards in the upcoming few months. For instance, if above normal precipitation is expected in flood-prone areas, it increases the risk of flood more than

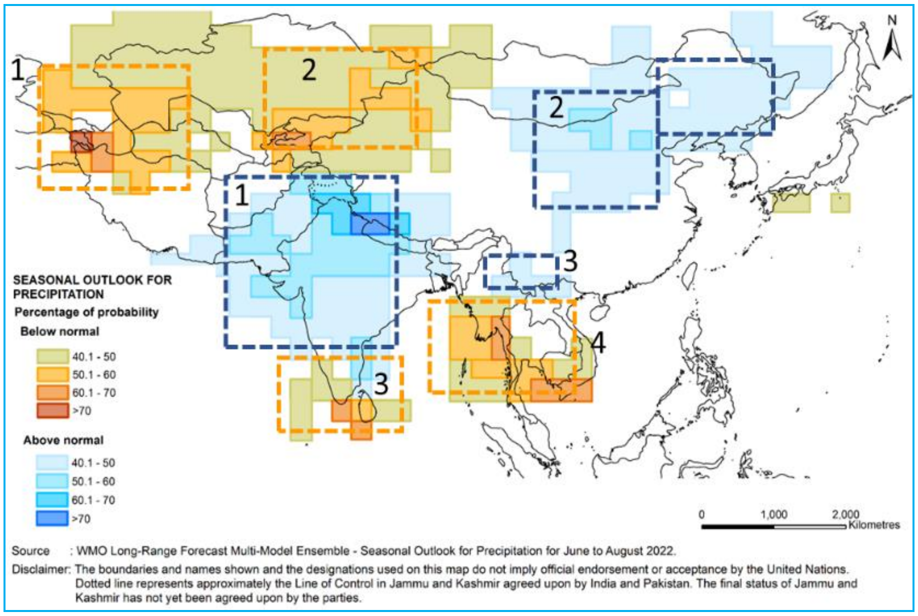


Fig. 8. Seasonal outlook for precipitation for June-August 2022, above-normal (floods) and below-normal precipitation (droughts)

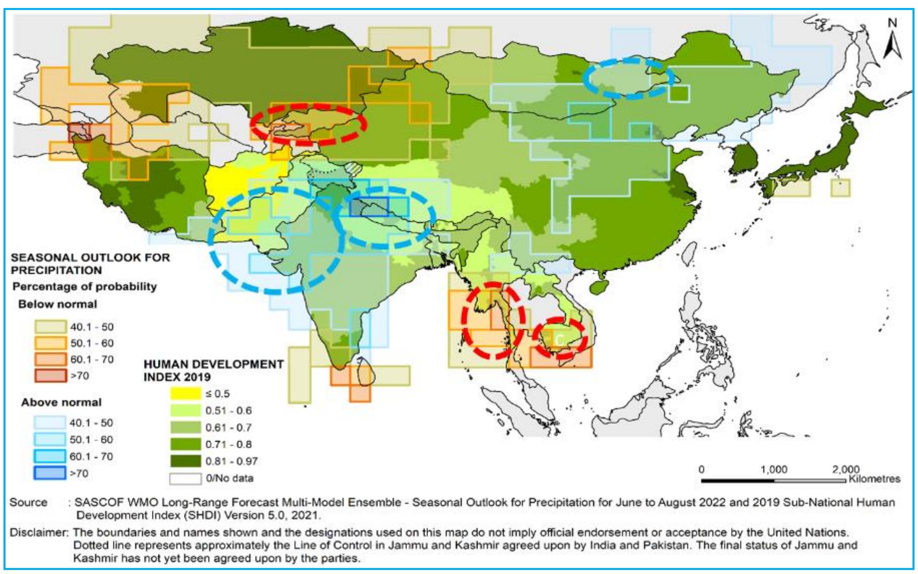


Fig. 9. Vulnerable population likely to be exposed to below/above normal precipitation

above normal precipitation in non-flood-prone areas. On the other hand, if below normal precipitation is expected in drought-prone areas; the risk is higher than below normal precipitation in non-drought-prone areas.

While this information is not enough for early action, it supports risk-informed and strategic decision-making for preparedness and policy interventions. National meteorological and hydrological agencies can closely monitor the developments of climate related hazards for early warning; planning ministry can reserve some resources ahead; and national disaster management authorities can monitor the developments of climate-related hazards as well as prepare appropriate measures in advance for early action. In the next section, impact scenarios show how the combination of hazard and exposure data can provide valuable insights on identifying risk hotspots (UNESCAP, 2021).

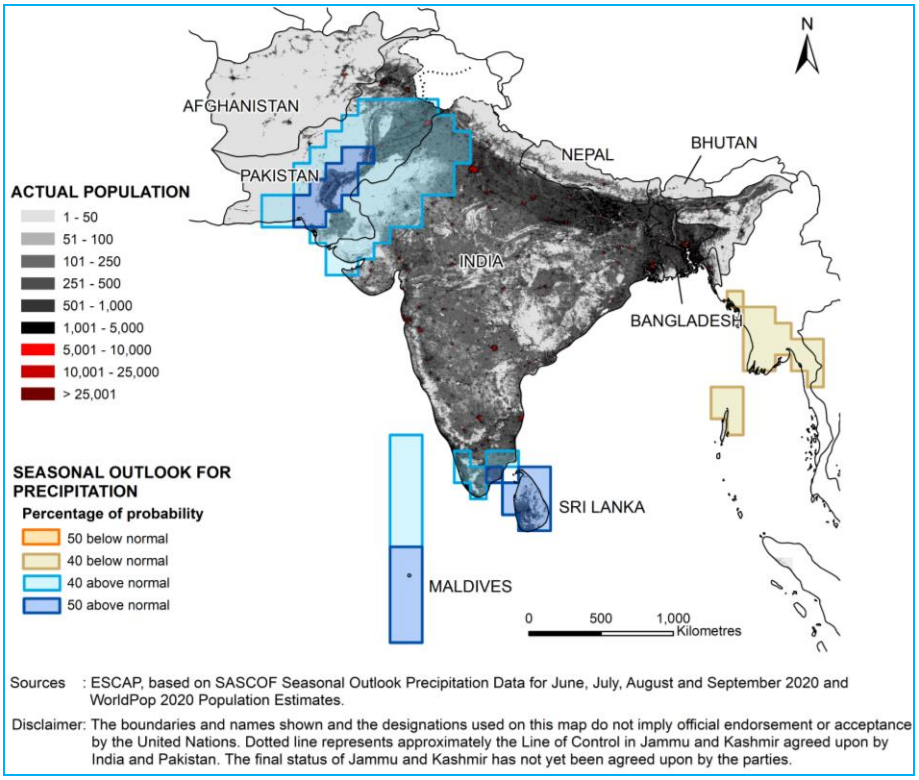
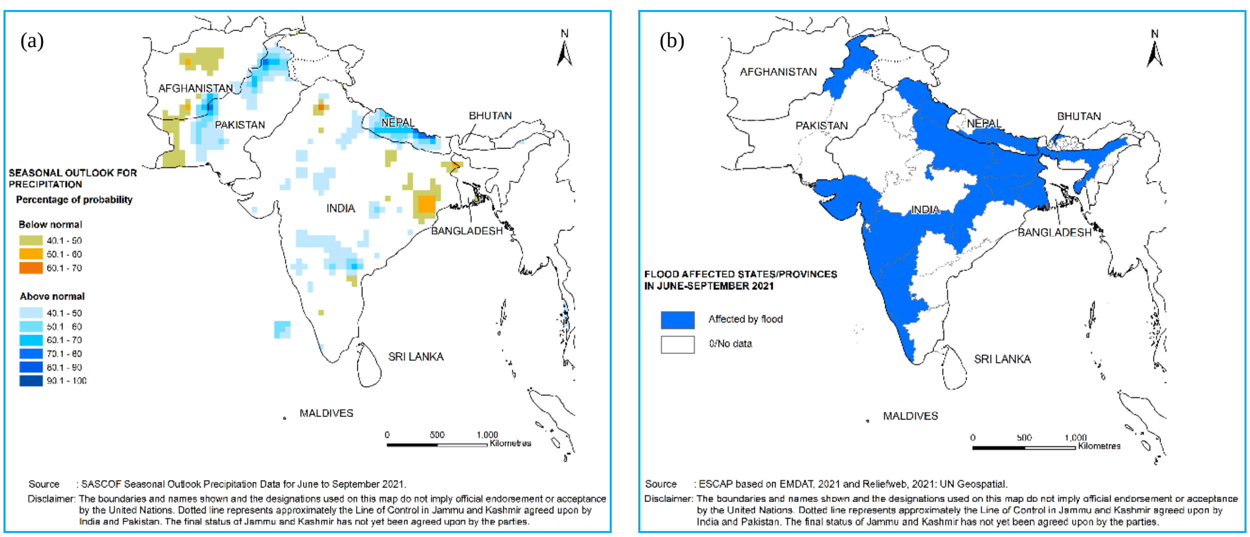


Fig. 10. Seasonal outlook for precipitation (June-September, 2020)



Figs. 11(a&b). Seasonal outlook for (a) Precipitation for June-September 2021 and (b) States affected by floods from June-September 2021

3. Results and discussion

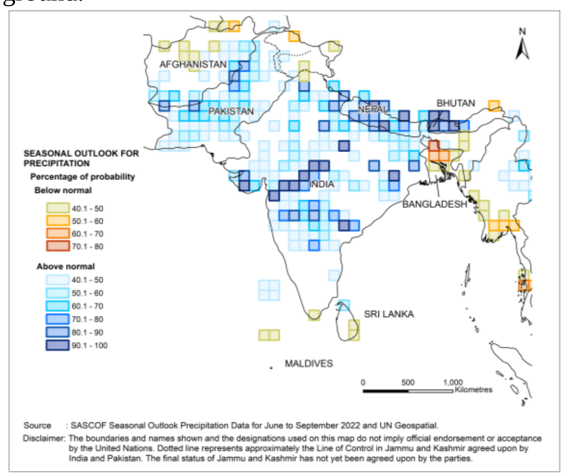
3.1. *Impact forecasting for floods and drought areas in Asia Pacific*

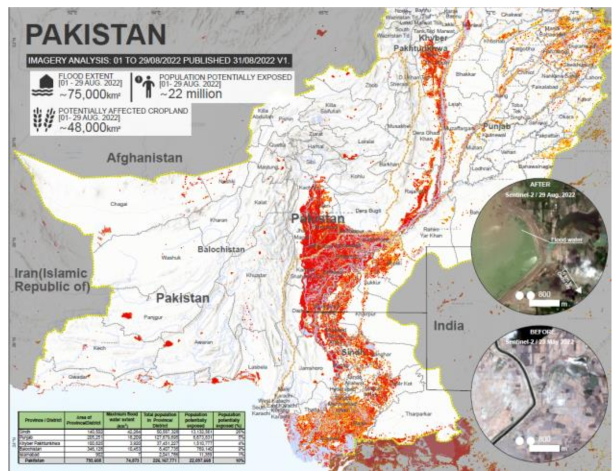
WMO Seasonal outlook for precipitation (ensemble) 2022 has been used to visualize the impact scenarios for June, July and August. In Asia, the specific areas have been identified with higher probability of **above-normal (floods) and below-normal (drought) precipitation**, which need attention for disaster risk management with much longer lead time (Fig. 8). For instance, Pakistan and North-Eastern parts of India, neighboring with Pakistan; Northern regions in India neighboring with Nepal and

Box 2 : Seasonal outlook for precipitation effectively warns against impending natural hazards

Starting June 2022, Pakistan has been facing one of most devastating floods in the country in decades. The floods have caused more than 1000 fatalities and affected 33 million people. In his recent address, Secretary General of the United Nations Antonio Guterres referred to this climate catastrophe a 'monsoon on steroids' and called for immediate relief action.

In this context, it is interesting to reflect on how seasonal outlook for precipitation can play a role in strengthening preparedness. The seasonal forecast from June-September 2022 brings forth the provinces likely to face above-normal rainfall. (Fig. 1) Broadly, hotspots that stand out in the forecast are the same as the provinces hit by the floods in Pakistan. These provinces include Sindh, Punjab, Khyber Pakhtunkhwa, Balochistan and Islamabad. This shows that despite certain limitations of seasonal forecasts related to granularity of data and probabilistic nature of the analysis, it **accurately identifies the hotspots of impending risks**. Hence, seasonal outlook for precipitation can prove to be an effective decision-making support for policymakers on the ground.





Box Figure : Seasonal Outlook for Precipitation, June-September 2022 (left), Satellite image of flood affected provinces in Pakistan (right)

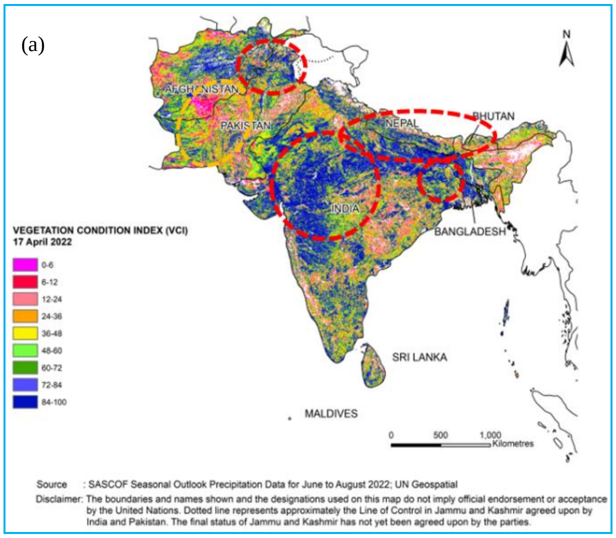
Disclaimer :
The boundaries and namesshown and the designations used on these maps do not imply official endorsement or acceptance by the United Nations.
Sources :
United Nations Satellite Centre (UNOSAT), published on 31st August, 2022, Available at : Link
UN News, Pakistan: $160 million UN emergency plan launched, as 'monsoon on steroids' continues, 30th August, 2022, Available at:Link

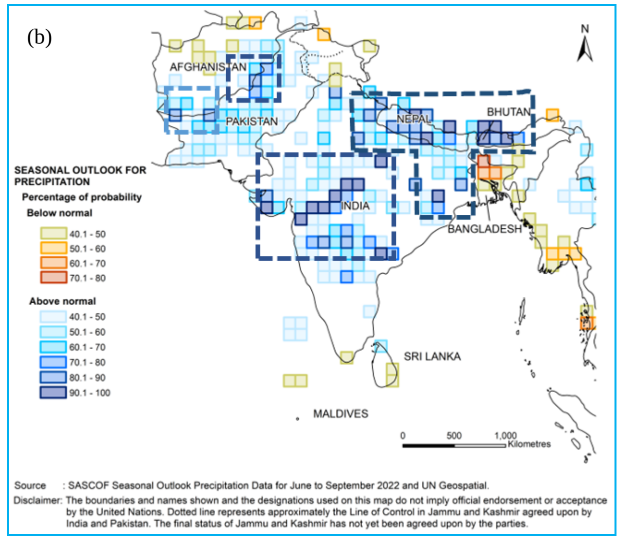
South-Eastern parts of China note 60-70% probability of above-normal precipitation. Some hotspots of below-normal precipitation include South-Western parts of Kazakhstan and Islamic Republic of Iran, Maldives and Southern parts of India as well as Southern parts of Myanmar and Cambodia.

As the next step, the seasonal forecast data can be utilized to identify the most vulnerable population by overlaying the seasonal precipitation outlook over the Human Development Index (HDI) in the region. Fig. 9 shows the hotspots of low HDI and above-normal rainfall in South Asia and North-East Asia and low HDI and below-normal rainfall in South-East and Central Asia. Identification of these hotspots of overlapping vulnerabilities from weather anomalies and low HDI can help policy makers direct their focus on protecting lives and livelihoods here.

3.2. *Impact forecasting for floods and drought areas in South Asia*

Data evidence validates the accuracy of seasonal forecasts, reiterating their utility for risk informed decision making. For instance, Fig. 10 shows the outlook for precipitation from June-September, 2020 overlaid with population density. Indeed, in August/September 2020, Pakistan was severely hit by heavy rains and experienced urban flooding with over 400 lives lost and around 305,000 homes partially destroyed. Further, studying the seasonal outlook for precipitation from June-





Figs. 12(a&b). (a)Vegetation condition index as of 17th April, 2022 and (b) Seasonal forecast for precipitation from June-September 2022

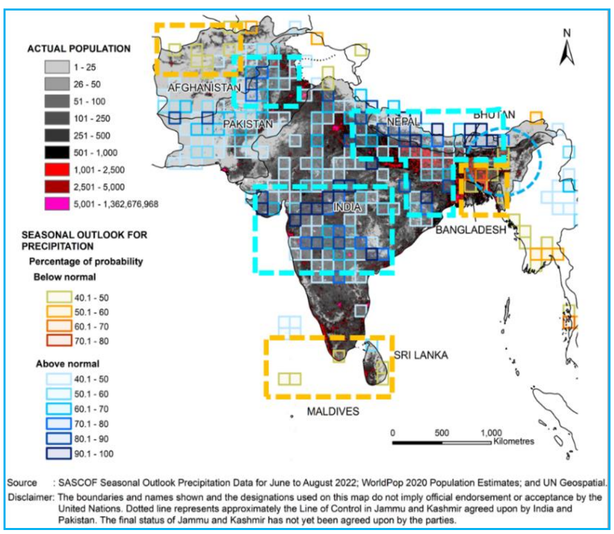


Fig. 13. Population likely to be exposed to above-normal and below-normal precipitation

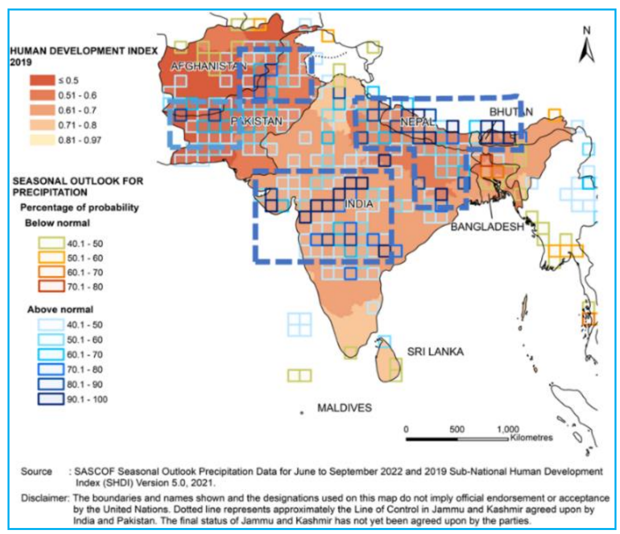


Fig. 14. Human Development Index and the seasonal forecast to understand vulnerability of people affected by floods and droughts

August, 2021 in South Asia alongside the states/provinces that were later affected by floods in the same period substantiates the precision of forecast data [Figs. 11(a&b) (Box 2)]. The following examples present some specific socio-economic sectors wherein impact based forecasting can be used effectively to inform decision-making and take anticipatory actions.

3.2.1. *A Vegetation health and seasonal outlook for precipitation*

Vegetation health alongside flood hazard maps can be used to identify areas of attention and action. For instance, the April 2022 vegetation index and the July-September 2022 above-normal precipitation outlook identify some hotspots like the North and Eastern parts of India, all parts of Nepal and Bhutan with 90-100 percent probability of above-normal precipitation [Figs. 12(a&b)].

3.2.2. *B Population density and seasonal outlook for precipitation*

Overlaying the precipitation forecasts over population density shows that in 2022, nearly 40 percent of the population in South Asia is likely to be exposed to

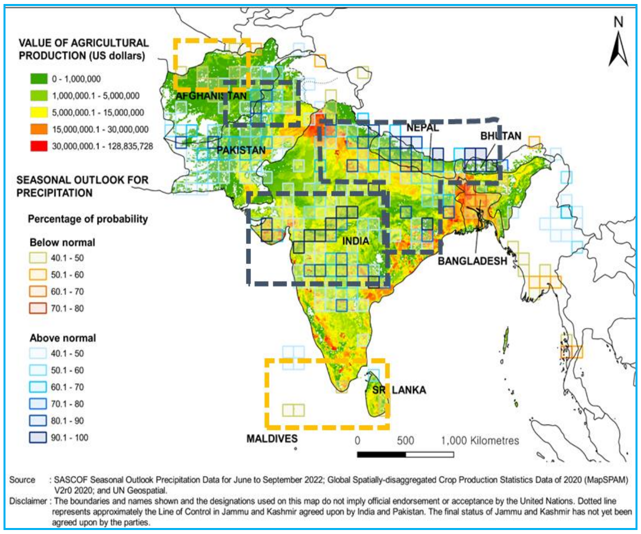


Fig. 15. Value of agriculture production and seasonal outlook for precipitation

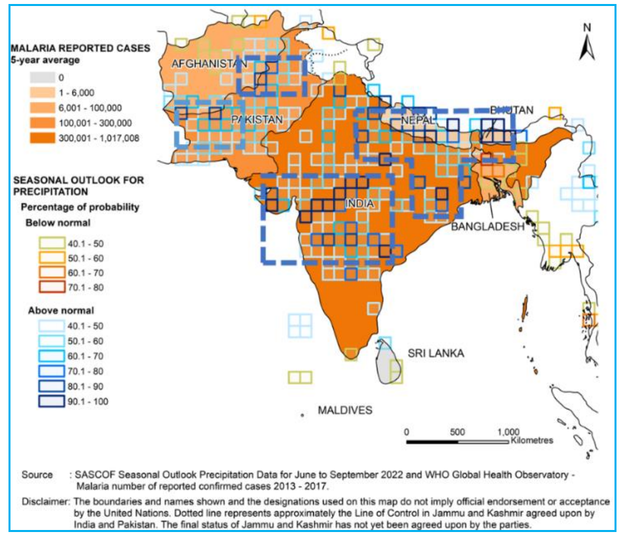


Fig. 16. Reported cases of Malaria (5-year average) and seasonal outlook for precipitation from June-September 2022

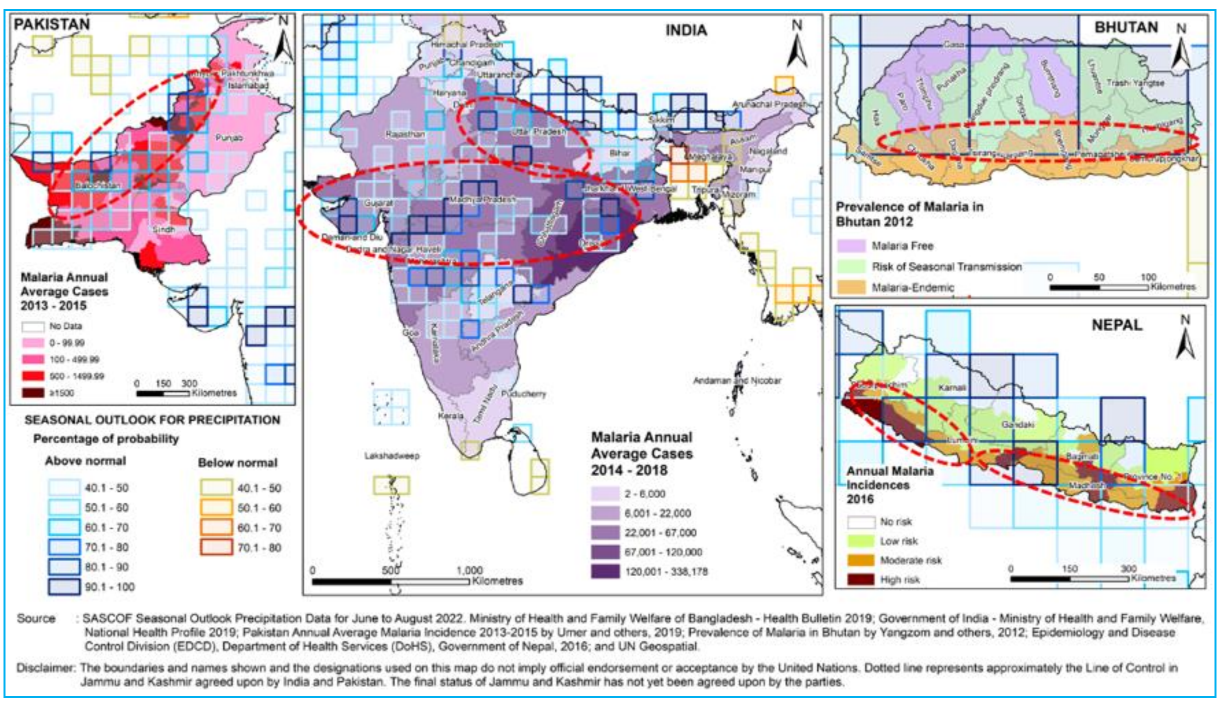


Fig. 17. Malaria risk and precipitation forecast at sub-national level

more than 40 percent probability of above-normal precipitation. Simultaneously, nearly 7 percent of the population in South Asia is likely to be exposed to more than 40 percent probability of below-normal precipitation. Overlaying the data evidence brings forth the hotspots of high population density at risk of above and below normal precipitation (Fig. 13).

3.2.3. *Human Development Index and seasonal outlook for precipitation*

HDI when over layed with precipitation forecasts brings out the hotspots of vulnerable populations exposed to precipitation anomalies. Other indicators like poverty, income, literacy etc. can also be studied alongside the

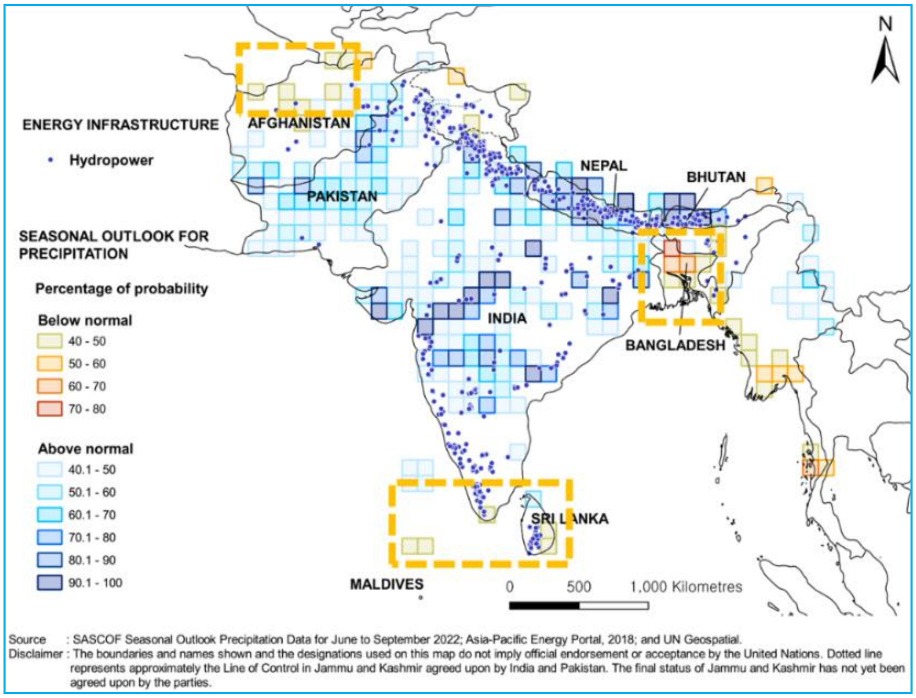


Fig. 18. Hydropower plants and seasonal outlook for precipitation

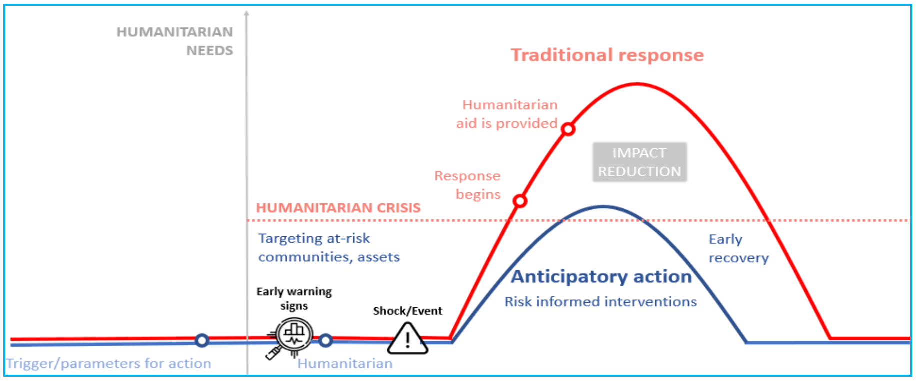


Fig. 19. Tackling crisis with anticipatory action

Source : Adapted from United Nations Office for Disaster Risk Reduction (UNDRR), Anticipatory Action

seasonal outlook to understand the vulnerabilities of population (Fig. 14). This exercise is critical as disasters impact vulnerable population groups more and decrease their ability to absorb shocks. The people then resort to coping mechanisms like decreasing nutritional intake and removing children from school which forms the root of long-term challenges like intergenerational poverty (UNESCAP, 2019).

3.2.4. *Agriculture production value and seasonal outlook for precipitation*

Overlaying agriculture production value on the seasonal outlook for precipitation in South Asia can present insights like nearly 7 percent of agriculture value in South Asia or nearly 6 percent of its agriculture production quantity are likely to be exposed to very high probability of above-normal precipitation (Fig. 15). This analysis is especially important for countries like India wherein agriculture accounts for 17 per cent of the country's GDP (UNESCAP, 2019). Adequate preparedness action can hence avoid excessive negative economic impact on the country.

3.2.5. *Health risk : Malaria cases and seasonal outlook for precipitation*

Overlaying the 5-year average of reported malaria cases with the seasonal outlook for precipitation brings forth multiple areas of attention like Northern and Eastern parts of India, Nepal and Bhutan, Central parts of Pakistan and neighboring Afghanistan with more than 90 percent probability of above-normal precipitation making these areas risk-hotspots for malaria (Fig. 16). Further, zooming into sub-national level risk can inform further targeted policy actions (Fig. 17). Indeed, increased risk of floods and cyclones bring along the vector borne disease outbreaks like dengue and malaria (UNESCAP, 2021). Hence, monitoring natural hazard risks *vis-à-vis* the related health risk can enhance overall preparedness and protect the people.

3.2.6. *Hydropower exposure and precipitation forecast*

Both above-normal and below-normal precipitation increase the risk to hydropower generation along with related facilities and services. Overlaying the hydropower energy infrastructure data on the precipitation outlook bring forth the hotspots that need attention. For instance, nearly 30 percent of hydropower plants in South Asia are exposed to more than 50 percent probability of above-normal precipitation, especially in parts of India, Pakistan, Nepal and Bhutan. Moreover, nearly 6 percent of hydropower plants in this region are exposed to below-normal precipitation, mainly in India, Bangladesh and Afghanistan (Fig. 18). This analysis can support authorities in preparing for potential disruptions in delivering hydropower-related essential services when hazard strikes.

4. Conclusion: Strengthening Early Warning Systems for building resilience

"*We must boost the power of prediction for everyone and build their capacity to act*", - Secretary General of the United Nations Antonio Guterres (UNESCAP, 2022). In his recent statement, the UN Secretary General emphasized the urgency for all stakeholders to build capacity such that every citizen is covered by early warning systems. Strengthening the early warning systems can play a pivotal role in taking anticipatory action, enhancing preparedness and reducing the impact of these hazards as indicated in Fig. 19. Early warning systems not only protect lives and livelihoods, but also help protect development gains in the long run.

Further, the Sharm-el-Sheikh Adaptation Agenda launched at the COP27 in Egypt, November 2022 highlights that, "Resilience is needed globally but starts with local adaptation solutions that depend on the specific context of geographies and communities and takes into account the needs and preferences of the most vulnerable people". Impact based forecasting can drive action at the local level (COP27, 2022).

Hence, impact-based forecasting and early warning systems must be adequately integrated at all levels for policymakers to boost the resilience and preparedness of communities at risk.

Disclaimer : The contents and views expressed in this study are the views of the authors and do not necessarily reflect the views of the organizations they belong to.

References

COP27, 2022, Sharm-El-Sheikh Adaptation Agenda : The global transformations towards adaptive and resilient development.

EM-DAT – The International Disaster Database. Available at https://www.emdat.be.

Food and Agriculture Organization of the United Nations. Global Spatially-Disaggregated Crop Production Statistics Data (MAPSPAM). Available at: FAO Map Catalog - Food and Agriculture Organization of the United Nations.

Global Data Lab and United Nations Development Programme (UNDP), 2021, "Subnational Human Development Index (HDI) Version 5.0 for 2019".

Global Framework for Climate Services (GFCS). World Meteorological Organization. Available at https://public.wmo.int/en/resources/bulletin/global-framework-climate-services

Government of India - Ministry of Health & Family Welfare. National Health Profile 2019 (2020). India State Wise Malaria and Dengue Cases, 2014-2018. Available at: http://www.cbhidghs.nic.in/showfile.php?lid=1147. Accessed on 7th August 2020.

National Oceanic and Atmospheric Administration (NOAA), National Centers for Environmental Information. Normalized Difference Vegetation Index. Available at: https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.ncdc:C01558

United Nations Office for Coordination of Humanitarian Affairs (UNOCHA), Reliefweb. Available at: https://reliefweb.int/

South Asian Climate Outlook Forum (SASCOF), 2021, Seasonal Outlook Precipitation Forecast for South Asia for June, July, August and September 2021. Received from RCC of Indian Meteorological Department in Pune, India.

South Asian Climate Outlook Forum (SASCOF), 2022, Seasonal Outlook Precipitation Forecast for South Asia for June, July, August and September 2022. Received from RCC of Indian Meteorological Department in Pune, India.

The Worldpop Population Estimates 2020, Available at : https://www.worldpop.org/

UN News, Pakistan : $160 million UN emergency plan launched, as 'monsoon on steroids' continues, 30 August 2022, Available at Pakistan: https://news.un.org/en/story/2022/08/1125752

UN News. UN weather agency to spearhead 5 year early warning plan, boosting climate action. 23 March, 2022. Available at: https://news.un.org/en/story/2022/03/1114462

United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), 2019, "Asia Pacific Disaster Report 2019", Available at: https://www.unescap.org/publications/asia-pacific-disaster-report-2019.

United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), 2017, "Asia Pacific Disaster Report 2017", Available at https://www.unescap.org/publications/asia-pacific-disaster-report-2017-leave-no-one-behind.

United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), World Meteorological Organization (WMO). Manual for Operationalizing Impact-based Forecasting and Warning Services (IBFWS). Available at: https://www.unescap.org/sites/default/d8files/knowledge-products/IBFWS%20Manual_FINAL.pdf.

United Nations Economic and Social Commission of Asia and the Pacific (2021). Seasonal Outlook to Socio-Economic Impact based Forecasting, Available at:https://www.unescap.org/sites/default/d8files/knowledge-products/Seasonal%20outlook%20to%20IBF_2.pdf.

United Nations Economic and Social Commission of Asia and the Pacific, 2018a, "Asia-Pacific Energy Portal", Available at: http://www.asiapacificenergy.org/

United Nations Office for Disaster Risk Reduction (UNDRR), n.d.: Understanding disaster risk, Anticipatory action, https://www.preventionweb.net/understanding-disaster-risk/key-concepts/anticipatory-action#pubs.

United Nations Satellite Centre (UNOSAT), published on 31 August 2022, Available at: https://unosat-maps.web.cern.ch/PK/FL20220808PAK/UNOSAT_A3_Natural_Portrait_FL20220808PAK_Pakistan_01Aug_29Aug2022.pdf.

World Health Organization (WHO), Malaria buren data: cases and deaths. The Global Health Observatory. Available at: Malaria burden data: cases and deaths (who.int)

World Meteorological Organization (WMO), 2015, WMO Guidelines on Multi-hazard Impact-based Forecast and Warning Services. Available at: https://library.wmo.int/index.php?lvl=notice_display&id=17257#.YxiBHnZByUk